CANADIAN ASSOCIATION OF OPTOMETRISTS
ASSOCIATION CANADIENNE DES OPTOMÉTRISTES

Teleoptometry and Artificial Intelligence

Opportunities and Challenges for the Profession
A Discussion Paper for OLF 2023

Healthy eyes and clear vision
for all Canadians, for life.

"AI is not an industry. Let alone a single product. In strategic parlance, it is not a "domain." It is an enabler of many industries and facets of human life: scientific research, education, manufacturing, logistics, transportation, defense, law enforcement, politics, advertising, art, culture and more. The characteristics of AI – including its capacities to learn, evolve and surprise – will disrupt and transform them all."

The Age of AI and Our Human Future
Henry A. Kissinger, Eric Schmidt, Daniet Huttenlocher
Hachette Book Group, 202

Teleoptometry and Artificial Intelligence: Opportunities and Challenges for the Profession

A Discussion Paper for OLF 2023

Key Concepts Defined - What are Telehealth and Artificial Intelligence? Debunking the Myths

Although telehealth and artificial intelligence are sometimes used in conjunction, they are two very different concepts.

The Canadian Association of Optometrists (CAO) defines **Telemedicine** as the process of utilizing modern telecommunication technologies to provide *clinical* service when the patient and the clinician are not in immediate physical proximity. The term **Telehealth** however, while often used synonymously with telemedicine, is a broader concept. It is a broader application of modern telecommunication technologies in clinical service, distance education, client outreach, triage, counselling, clinician-to-clinician communication and other applications wherein electronic communications and information technologies are used to support health services.

Teleoptometry as defined by the Federation of Regulatory Optometric Authorities of Canada (FORAC) is "[T]he provision of vision and eye health services that are delivered within the scope of practice of optometry using electronic health information, medical and communication technologies, and in the absence of physical contact between the provider and patient." Teleoptometry, therefore, can mean many different things, from telephone triage to video consultations and remote examinations. It can also mean virtual consultations with ophthalmology or at home patient monitoring. Teleoptometry, like tele-nursing, is a form of telehealth.

Artificial intelligence (AI) leverages computers and datasets to mimic the decision-making and problem-solving capabilities of the human mind. AI encompasses sub-fields of machine learning and deep learning, which are algorithms seeking to generate systems that can do predictions or classifications based on input data. The way in which machine learning and deep learning differ is in how their algorithms learn. **Machine learning** is dependent on human intervention to process data, whereas **deep learning** automates much of the process, eliminating some of the manual human intervention needed, and allowing the use of larger data sets. This enables deep learning algorithms to ingest unstructured data like images and text in its raw form such as retinal or X-ray images **(feature learning)**.

AI already offers many practical applications in our day-to-day life, including speech recognition (e.g., Siri and Alexa), customer service (e.g., messaging bots used in Facebook Messenger), computer vision (e.g., screening from retinal imaging or self-driving cars) and recommendation engines (e.g., Google, Amazon, or Netflix). All these types of applications are increasingly affordable and easy to implement. As health data becomes more and more available to researchers, their full deployment in healthcare is imminent. That being said, AI is not at the point where it can replace people, but rather assist in the data collection and clinical decision-making processes.

Advances in Telemedicine and Artificial Intelligence and their Application: Putting Optometry in Context

ARTIFICIAL INTELLIGENCE

"Adopting [artificial intelligence] too early could be costly, but adopting too late could be fatal."

-Ajay Agrawal, Joshua Gans, Avi Goldfarb. Prediction Machines. 2018.

Artificial Intelligence (AI) can be found almost everywhere. Facebook and other social media platforms use it to monitor which posts you like to specifically tailor the advertisements to what you interact with. Amazon shows you a variety of similar items you might like when making a purchase, based on your browsing history. The development of object recognition in 2012 now allows AI to drive the "autopilot" on Tesla vehicles. In 2014, Google paid $600 million to acquire DeepMind, and continues to invest heavily in AI initiatives. Currently, even your Apple watch is collecting your data (your sleeping habits, physical activity level, family and medical history, age, etc.), and combines that information with its ability to measure heart rate to better predict those who are at risk of a heart attack. Initiatives like these can quite literally save lives.

AI provides us with a key component to human intelligence: prediction. AI takes all the information available and uses it to generate information you don't have. Consider any decision made during a normal working day as an Optometrist: When should you bring in a new product or technology? Which candidate should you hire? Do you consider a recent frame that sold a 'hot seller' or was it a fluke that it sold so quickly? Is this retinal nerve fiber layer showing progressive loss indicative of glaucoma? AI could be employed to help better predict the answer to each of these questions. Increased predictive ability can reduce uncertainty in all aspects of optometry, from how the business is run, to how optometrists care for their patients.

AI has the potential to impact the eye care industry in three key ways:

1) Improve diagnostic/prognostic predictions

Radiology was an early adopter of AI to improve predictive power. AI is being employed so it more accurately identifies cancer, early Alzheimer's and Parkinson's diseases, circulatory and connective tissue problems, and more. Radiology benefits from having large databases of publicly accessible images on

which to base new predictions.

As the cost of prediction becomes cheaper, it increases the value of expert judgment. Even with improvements in accuracy and speed, the expertise of radiologists is still necessary to verify the predictions and to ensure that the correct value has been placed on the prediction outcomes. Human involvement will always be necessary to determine the relative payoff associated with each possible outcome, including those associated with the "correct" decision and those associated with mistakes.[1] Consider treating a glaucoma patient: with drops, your patient may run into side-effects such as conjunctival hyperemia and eyelid pigmentation; doing nothing puts the patient at risk of permanent vision loss or blindness. For a human, the judgment in this situation is easy, as the cost of inaction is potentially severe, and most optometrists would choose to treat the patient to avoid this outcome. AI's most significant weakness is that it sometimes provides the wrong answer but is highly confident that it is correct. Therefore, human judgment will always play a role in ensuring that the prediction makes sense for a given scenario. Predictions will become more accessible, cheaper, and more accurate. However, health care experts will always be necessary to ensure that these predictions are judged appropriately to ensure the best patient outcome.

In 2016, a Harvard/MIT team's deep-learning algorithm was shown to significantly decrease the error rate when identifying metastatic breast cancer from biopsy slides. The AI algorithm made the correct metastasis diagnosis 92.5% of the time. The human pathologist's performance was correct 96.6% of the time. When combining the algorithm with the pathologist's, prediction, accuracy climbed to 99.5%.[2] Patient outcomes can be improved when utilizing AI to help inform our decision-making as healthcare providers.

More recently, AI has been applied in genome sequencing. AI helps to systematically look at thousands of loci at a time in the genome, screening through millions of molecules to test which molecules result in which genes. These massive parallel reporter assays are helping to locate over 120,000 diseases that scientists want to locate on the genome. With this information, doctors could truly start providing individualized care, based on everyone's unique genetic make-up.

2) Improve access to care

Where there is a shortage of qualified clinicians, such as in Canadian rural and remote communities, AI may be able to perform some preliminary diagnostic tasks which clinicians typically perform.[3] Radiology is already harnessing this technology to verify the predictive results of X-rays and neuroimaging half a world away from where the patient is located. As wearable devices become more commonplace, AI will likely play a role in predicting when intervention might be appropriate. For example, your child's smartphone could warn you that the amount of near work they are doing may be causing risk of myopic progression.

3) Improve business predictions

AI is currently being used for trend identification, sales predictions, target marketing, human resources, and customer retention. One example of a heightened area of AI resources is turning to improving forecasting of customer churn (percentage of patients who stop using your services or products over a given time frame). New customers are very expensive to acquire, so losing them is costly. AI can be employed to reduce this customer churn and help to capitalize on acquisition costs. For optometrists, this may lead to improving

internal marketing by identifying patients at risk of leaving the practice. For example, an AI algorithm may find high rates of customer churn in patients of a certain age or demographic and identify possible opportunities to serve them better. AI can help predict the loss of these patients so you can target your marketing more accurately to retain them before they've made the decision to leave the practice. Likewise, AI can also help identify which patients need extra staff time, have referred the most others to you or have been most loyal purchasers of products and services. This can make your service to patients more customized, effective, and efficient. Finding and retaining good staff members is a priority for any business. AI will make it easier to predict which new hires and staff members will stay on longer and continue to be an asset for the business. Inherent biases are commonly reflected in these predictions. In order to avoid such biases (e.g., gender bias, racial bias, socioeconomic bias, etc.), developers are doing their best to identify human biases reflected in their algorithms and correct for them manually. The process is not perfect yet, but this is an area of rapid development which has the potential to improve the hiring process across all businesses.

It is a common misunderstanding that AI will replace human expertise. Consider the possibility of new technology available on a phone that predicts intraocular pressure. As the cost of these predictions becomes less expensive, it increases competition for who can measure intraocular pressure. This does not mean optometrists will be out of a job. On the contrary, optometrists remain the experts needed to judge if, when, and what intervention is necessary. It is up to optometry's leaders to ensure that the profession is positioned to take advantage of these opportunities, and to ensure that optometry has a seat at the table that legislation and regulations reflect our professional obligation to utilize this technology appropriately and effectively.

Thoughtful implementation of teleoptometry will reduce barriers to eye care by providing quality care no matter where a patient might live.

TELEHEALTH

Although telehealth has been gaining in popularity for decades, the COVID pandemic certainly expedited and expanded its utilization. Although once considered exclusively for remote care when clients were located a considerable distance from their health care team,[5] many clients now prefer to access services via telehealth due to convenience. Patients can access care where and when they need it.

Telenursing (a form of telehealth) has been employed successfully in a variety of circumstances including pre-and post-operative evaluation, monitoring chronic conditions with the use of a home electronic stethoscopes and blood pressure cuffs,[6] and mental health evaluations and counseling. Just recently, a Calgary team of nurses received a grant to employ telehealth within their post-discharge program for preterm babies. This service was embraced by families because it allowed this vulnerable population to be safely monitored in the comfort of their own homes.[7]

Specialists, such as cardiologists, radiologists, and others, are increasingly relying on telemedicine to interpret diagnostic findings for patients located a significant distance away.

Access to online primary care practitioners and counselors is becoming increasingly commonplace. Examples of readily accessible telehealth in Canada include the Kids Help Phone and the health care lines

available in all provinces and territories. There are a variety of examples of telehealth now being deployed by private insurers which provide accessible virtual care from smartphone applications.

Many of these current platforms, though, do not include optometrists on their panels of experts. There are regulatory concerns, as some of the available practitioners employed by these corporations are often located out of province (and possibly country) from the patients they interact with. There is an advocacy opportunity for ensuring optometry is included in the panels of experts associated with various telehealth platforms.

As primary eye care professionals, direct-to-patient telehealth ensures that optometrists can reach those who would otherwise be underserved. Through our collective experience with the coronavirus pandemic, it is clear there is a desire amongst the Canadian population for access to care when and where they want it. With the opportunity to be the first point of care for many patients, this allows optometrists to help ensure patients navigate a challenging health care system, so they are monitored and co-managed with other health care providers as necessary.

With Canada's aging population, the need for improved access to care is more important than ever. This collaborative model allows patients to stay within their communities if it is not necessary to intervene. Telehealth also aids in communication between optometrists and other health providers in the form of e-consults. This is particularly true for ophthalmologists, who are primarily located in major Canadian centers which can be a barrier to care for many Canadians.

Indeed, as the primary eye care providers, optometrists are the best suited professionals to utilize telehealth platforms to improve eye care and ensure all Canadians have access to it.

Clinical Applications in Optometry

Online platforms utilizing AI can automate care where possible, identify at-risk patients, and provide the range from digital triage to higher levels of care for those patients when necessary. Online intake forms with AI chatbot functionality can efficiently complete intake tasks and direct patients in an appropriate manner towards phone calls, video calls, or scheduling in-person consultations with the most appropriate care provider. Utilizing these approaches could improve access to care, enhance care coordination, optimize telehealth initiatives, improve the patient experience, and deliver better outcomes. The platforms can also be utilized to deliver timely instruction and education before and after exams and enhance remote patient management and treatment compliance.

Clinical and operational benefits include improved patient satisfaction, engagement, care plan adherence, reduced follow up visits, lower no show/cancellation rates, and better care team coordination and productivity. Automated and live virtual care are increasingly being used to complement in person care delivery.

Patients are increasingly expecting access to care anytime, anywhere. Providers, therefore, need an effective and efficient way to monitor, manage and communicate with their patients. AI-enabled platforms

can help gather health data, analyze it, and navigate patients along personalized journeys down evidence-based pathways.

Process automation applied to the triage phase of the patient journey can seamlessly integrate 24/7 live or automated chat (available in multiple languages) with an office website to capture prospective patients directly into the scheduling system. With consent obtained digitally, the practice can collect billing information, patient information, chief complaint, and medical history that pre-populates the patient chart in an integrated electronic medical records system (EMR) before they are guided towards a telehealth or in-person appointment. This approach is increasingly being used as the primary method for patient intake and triage in fields other than optometry, such as family medicine.

AI can serve as an assistant to help organize the clinic visit by triaging patients and providing a working diagnosis, determine the appropriate testing and room requirements, and anticipate the procedures or referrals (if any) that may be needed for a patient. The optometrist can then conduct a more focused, efficient, and effective evaluation and management of the patient.

Depending on the reason for the patients' visit, the severity any condition they might present with, and the patient's location, the optometrist may not always need to immediately be in the same room at the same time as the patient. An image can be obtained by an assistant and that image can be interpreted by an AI system before being forwarded to an optometrist. Ideally, the patient can then be scheduled to be seen by an optometrist at an appropriate time depending on severity.

There are obvious shortcomings of this asynchronous care model as a stand-alone exam. Just as case history questions need to be adapted depending on responses, examination of the fundus, anterior segment, use of vital dyes, manipulation of lids, extent of eye coordination testing all depend on the findings of the initial evaluation of each of these, just to name a few. For this reason and others, a synchronous exam would have significant advantages.

Other than patient intake and triage, AI and virtual reality can be used for training (e.g., gonioscopy) as well as patient education, explaining conditions and their prognosis for diseases and conditions, such as AMD, glaucoma, cataracts, and others, as well as treatments options. AI could also be used to adjust specialty contact lenses more accurately such as Ortho-K.

Current platforms can both predict diabetic retinopathy as well as classify it as mild, moderate, or severe non-proliferative or proliferative retinopathy. Algorithms such as IDx-DR are currently approved by the FDA to diagnose diabetic retinopathy4. It has been trained and validated on over two million images to mitigate bias and ensure the system works equally well for all people, regardless of sex, or race. IDx-DR was validated against patient outcomes using a surrogate outcome standard and was found to correctly refer 100% of patients with at least moderate diabetic retinopathy and more than 96% of patients with diabetic macular edema. As a screening tool in place of primary eye care, IDx-DR avoided 91% of unnecessary specialty visits by capturing a result that is negative for diabetic retinopathy and macular edema.

At the 2021 American Academy of Optometry meeting, Dr. Jessica Steen, OD, FAAO, Dipl-ABO, reviewed some AI technology currently under development, including a device for detecting CNVM with OCT. This at-home device would improve response time for detecting bleeds associated with macular degeneration.

Dr. Steen also outlined how AI is currently being developed to improve prediction of what some would consider the most complex ocular diagnosis, glaucoma. There are currently multiple risk factors needed to consider when evaluating a patient for glaucoma, and even for experts, it can be hard to weigh the importance of each of these risk factors towards a diagnosis or prognosis. But are there other, unknown risk factors that only deep learning could identify? AI could also help with predicting prognostic decisions, such as timeline for disease progression, drug of choice, risk to fellow eye, when to refer, etc. Once AI improves predictions in this area, researchers are working on how to reverse engineer an OCT from a digital image. This technology could significantly improve care in areas of the world where OCT's are difficult to access. As myopia management increasingly becomes the standard of care, AI could be effectively used in assisting the optometrist in designing and implementing individualized preventive and treatment plans.

Increasingly, AI is being used as a preventive medicine tool, identifying, and analyzing risk factors and dispositions, and proposing individualized courses of action. Despite these exciting advances, there is no replacement for a well-trained clinician with common sense. With the reduction in time necessary for data interpretation, AI will allow practitioners to counsel in a more meaningful way to ensure patients truly understand the importance of adherence. Optometrists generally excel when it comes to patient communication, so counseling, discussing, and answering questions for patients will continue to hold value into the future.

Potential Impact of Teleoptometry and AI on the Future of Optometric Practice in Canada

Research and development conducted by both industry and academic institutions suggest that there are many changes coming in optometric practice. It is therefore imperative that optometrists both understand and embrace these changes and new technologies for optometry to claim its space in the eye health and vision care sphere. It is anticipated that advances in technology, telemedicine and AI will impact the practice of optometry in three broad areas:

1 - Optometry clinics

Increase in automated objective and subjective data, supported by AI

New technologies are playing an increasingly important role in optometric practice as they provide objective, quantifiable and documentable data. Automated devices are already being used. However, several components of the visual examination must be performed by the eye care provider as the in-person comprehensive eye exam is still considered the standard of practice. With the rapid technological advancements specifically in aspects of AI including machine learning, deep learning, and feature learning and with their rapidly increasing accuracy, it is anticipated that more and more aspects of the eye exam will become automated.

Examples of new technologies that are currently being developed or marketed include:

- Automated subjective refraction,

- Pupillary reflex assessment
- Motorized (synchronous) slit lamp examination of the anterior segment, and
- Assisted lens centration measurement with 3D face scanning and augmented reality.

Automated subjective refraction systems using a machine/human interface can make it possible to systematize and personalize refraction based on parameters such as age and an accommodative status of the patient. An optometrist would presumably only need to redo the refraction in cases where the AI system has identified inconsistencies or abnormal results. Other aspects of the eye exam could also be automated, so that the eye care provider would only need to repeat certain tests. While this transition could take several years for the technology to become sufficiently reliable, they could positively change optometric practice like that of radiology.

Diagnostic Treatment-Aid Systems

Another aspect that could radically change the practice of optometry is "diagnostic aid systems". AI systems use large databases to grow diagnostic-aid algorithms. Several systems are already deployed to screen for diabetic retinopathy, AMD, glaucoma, and dry eye. Although these aids make it easier to screen for specific eye conditions, they are not yet able to systematically screen for multiple conditions, however many are currently in development. Such systems will likely be adopted for other eye diseases as well as looking beyond eye care into general health. AI work is being done by countless researchers and companies to use the eye as a window into the health of patients, with applications ranging from common ocular diseases to hypertension, CVA, risks of myocardial infarction, Alzheimer's disease, and others.

Tele-eye care

Triage and home-based self-testing devices

Key industry players are working on developing eye emergency triage platforms that can categorize ocular emergencies and allocate them according to available resources such as hospitals, optometry, or general practice clinics. The rise of these platforms goes hand in hand with the emergence of home-based self-testing devices that allow the partial assessment and monitoring of certain eye conditions (i.e., online triage or monitoring questionnaires, app-based visual acuity and photo-documentation, videoconferencing, etc.)

Synchronous Teleoptometry

An increasing number of components of the comprehensive eye exam can now be performed remotely with a patient in the clinic while the optometrist is at a distance. This model makes it possible to examine patients in areas where there is shortage of optometrists such as in northern Canada.

Technology now makes it possible to connect all automated instruments to a tele-optometry platform and/or to an electronic medical record (e.g., Digital Optometrics, Axis Medical, Topcon, Tecksoft, etc.) The optometrist can thus remotely review all the pre-tests (lensometry, autorefraction, visual field, fundus images, OCT, topography, etc.) before starting a video conference with the patient. (This model is growing rapidly in the US as a solution to "dark locations" at optical chains locations who are very motivated to have a virtual eye doctor rather than none at all. Example: 2020now outfitting Walmart, Sam's Club and Costco

where they are already in 250 locations and 170 more are projected within the year as of April 2022).

The case history can be started by an assistant or by using a pre-visit web-based customizable form. The optometrist must confirm the relevant information during the video conference. Interactive questionnaires with questions that adapt to patient responses are also under development. Certain components of the eye exam cannot be performed automatically and require the presence of an assistant (e.g., cover-test, eye movements, etc.). These tests can be streamed live for synchronous evaluation or recorded for asynchronous reviewing by the optometrist. Other tests can be controlled remotely by the optometrist, such as subjective refraction and binocular vision tests that are included in the remote phoropter. Currently, performing and interpreting some of these tests at distance is still a challenge because of the technical difficulty of the tests (e.g., slit lamp of the anterior segment) or because the remote interpretation is complex (e.g., cover-test, pupillary reflexes).

In this model of synchronous teleoptometry, the optometrist should be familiar with the health care system of the patient's geographic region. The optometrist must know the available resources and be able to refer the patient when required. In Canada, optometrists must follow their provincial regulator's guidelines on teleoptometry. Where such guidelines do not exist, FORACs guidelines should be adhered to.

Asynchronous Tele-Eye Care Business Models

Traditionally, asynchronous tele-eyecare has involved an eye examination in person with an optometrist, followed by the data obtained being forwarded to another health care provider for co-management and second opinions.

The emergence of new technologies is changing several business models towards asynchronous tele-eye care models whereby assisted automated tests are performed which the eye care provider can then review before speaking with the patient. With some tests being performed remotely, most of the chair time could be spent interpreting and managing the results with the patient.

Other models offer asynchronous care without direct human intervention, such as the monitoring of certain eye emergencies or the replacement of glasses with web-based refraction systems. Although the reliability of such models remains debatable, they are closely examined and increasingly being deployed by the industry.

2 - Data and Communication

Soon, new parts of the visual examination such as the automated cover test, pupillary reflexes, or anterior segment biomicroscopy will become automated and photo documentable. All this new data will feed large cloud databases and deep learning systems and consequently increase their reliability and accuracy.

The future of optometric practice must continue to evolve with available technology. It is important to be part of this process to properly regulate this evolution for the benefit of patients.

Considerations

With the diagnostic predictability of AI improving rapidly, it has the potential to provide accuracy that closely resembles in-person diagnosis. Together, AI and the optometrist have been shown to increase the accuracy of diabetic retinopathy diagnosis to close to 100%. In the Canadian context, especially in remote northern Indigenous communities, teleoptometry and AI may, in fact, be the most cost-effective modality of providing certain preventive, diagnostic and therapeutic vision care services. There are currently a few initiatives including:

- BC Doctors of Optometry is working with the First Nations Health Authority to provide hybrid care by deploying remote comprehensive eye exam lanes into regional health hubs to supplement monthly in-person eye care with teleoptometry exams on demand.
- The University of Montreal's School of Optometry implemented diabetic retinopathy screening in more than twenty Indigenous communities.
- The School is also conducting research on remote refraction and comprehensive eye exams compared with in-person refraction and exams, as well as on 3D facial scanning using handheld devices.
- The University of Waterloo School of Optometry and Vision Science is pioneering teleoptometry programming in Indigenous communities on Manitoulin Island in Northern Ontario, as well as AI research in collaboration with the University's schools of engineering and mathematics.

These examples (and others) represent a movement to embrace teleoptometry and artificial intelligence by Canadian optometry. The common theme among the examples provided is the drive to provide vision care to disadvantaged, remote and Indigenous communities, using teleoptometry and AI as means to providing more equitable care at a quality level that might be equivalent to in-clinic care.

AI can-and will-aid in improving prediction for diagnosis, prognosis, and treatment. If developed properly, AI may make optometrists better and more efficient at what they do-diagnose and treat visual and ocular conditions.

There are some further considerations about the use of teleoptometry and AI in practice

1 - Acceptability

Teleoptometry and AI are changing the modality of how care is administered. With teleoptometry improving access and AI improving predictive reliability, these technologies will facilitate improved patient care.

While necessary, this is not sufficient for large-scale acceptance of teleoptometry and AI. Incentives for different stakeholders are necessary. Optometrists must be fairly remunerated by both public and private insurers for teleoptometry services. Patients need to see better and more convenient service; insurers, public and private, need to put in place the administrative and managerial structures and systems that can address teleoptometry and AI-the creation of billing codes is one example–and lastly, teleoptometry and AI cannot come at a higher cost to the system than in-clinic care.

2 - Data ownership, privacy, and cybersecurity

In Canada, the collection, storage, transmission and otherwise use of personal data must comply with the provisions of the **Personal Information Protection and Electronic Documents Act** which stipulate stringent security and privacy requirements for patient information. The only exception is the Federal Government for which the **Privacy Act** applies.

For AI and machine learning to work, large volumes of data are required. The optimal way to store and use patient data securely is to do so on a separate protected machine. However, this will limit the amount of data that is available for effective AI and machine learning. Cloud storage is therefore increasingly used because it accommodates pooling data from multiple sources. This, in turn raises issues of data ownership, privacy and governance which, in turn increase the risk of non-compliance and data security. A third model is beginning to emerge whereby proprietary data remain protected while the AI algorithm is made available for practitioners to use.

In vision care, AI and machine learning have primarily been focused on analysis of retinal images to screen for diabetic retinopathy. This is making it more accessible to population groups who had limited access to it before. For the most part, however, these systems depend on large volumes of images that have been pre-assessed by humans. This makes the accuracy of these systems only as good as that of the human assessors who provided the information. Deep learning will be expected to change that.

3 - Accountability

The increasing use of automated systems such as chatbots raises some accountability issues. The optometrist is always ultimately responsible for the vision care provided to their patients. The potential for an automated system making an error that results in patient harm, requires serious examination and resolution.

As machine learning is deployed to include millions of ocular images, there is also a need to ensure the predictions that algorithms make are appropriate. Inherent biases within the datasets can influence the algorithms produced by AI. Data sets need to be fully representative of a population in which they are deployed to avoid such biases, and if the biases are known, they can be accounted for within an algorithm. Perhaps no human could ever ascertain someone's race, sex, or age from a fundus photo, but with millions of data points, could these images become true biometric measures? If so, patient privacy cannot be overlooked. If the technology develops in this way, the potential consequences, like insurance agencies requiring fundus photos as part of their evaluation, raise some significant concerns.

4 - Separating the Components of the Comprehensive exam

While new technologies increasingly allow the automation of different components of the eye exam (for example, remote fundus photos), the in-person comprehensive exam should remain the standard of practice to aspire to through the provision of teleoptometry and in the development of artificial intelligence diagnostic technologies.

Teleoptometry in Practice

Teleoptometry came to the forefront in Canada as an option for delivering clinical care during the COVID-19 lockdown of 2020. Since then, teleoptometry is increasingly being viewed and considered as a viable option for providing clinical care to population groups with access challenge, especially in remote, rural, Indigenous, and northern communities. The optometry schools of the University of Montreal and the University of Waterloo are already engaged in teleoptometry and AI pilots serving Indigenous communities. So is BCDO. To incorporate a more practical perspective to this discussion paper, CAOs Teleoptometry and AI Taskforce conducted interviews with two Canadian clinicians currently practicing teleoptometry. For privacy reasons, the following interview transcripts were edited only to remove identifying information. The same six questions were asked of both clinicians. Due to the nature of this document, being a discussion paper, we present the transcripts with no commentary:

Interview 1:

- **When did you start providing telehealth? Walk us through a typical encounter. (e.g., describe synchronous or asynchronous care).**

I started providing synchronous telehealth for patients in early 2022. I do a mix of telehealth exams as well as travel to the community for in-person clinics a few times a year. Telehealth exams work similar to regular exams in that the patient receives the same pretesting, the same exam structure, and I interact with them in real time. I rely on the technician to move the equipment into place but am able to control several aspects of the technology remotely. Generally, I am very happy with the views I can obtain but there are some structures of the eye that are more difficult to evaluate. If there is question on diagnosis or further testing is required, I will have them return when I am in the community or present to the local hospital for triage and possible travel to a larger center if more urgent. For routine care, the current setup works excellent.

- **Were there any barriers you've faced when setting up telehealth? (e.g., training of techs/ nurses?) What about barriers to provide appropriate care? (e.g., perhaps not accurate enough equipment to actually diagnose assumed iritis virtually?)**

One of the barriers for telehealth exams is relying on fundus photography for ocular health assessment. Fortunately, in the current setup, if any patient has Diabetes or requires a peripheral retinal exam, they can be seen for that testing during an in-person clinic. Another barrier would be relying on adequate internet connection. Fortunately, this has not been an issue so far but could pose a problem. Lastly, NIHB does not yet cover telehealth exams, so this creates a barrier to access to care in this population.

- **What are some benefits you have found with telehealth? What do patients say about it?**

So far, patients have been very receptive to teleoptometry. Their first impression of the exam room is that it seems like any other but when they see me on the screen, they are usually intrigued. There have been no complaints of sub-par care.

The largest benefit is ease of access for patients, so they don't have to wait two months to see an Optometrist just to update their prescription. It also lightens the load on in-person examinations for when I am physically in the clinic.

- Where do you see telehealth and Optometry in 10 years?

I still see a place for in-person examinations; however, I believe every clinic will do a better job of incorporating teleoptometry for many follow-ups and refraction updates. If another pandemic were to happen 10 years from now, Optometry should be much better positioned to respond and keep clinics open by continuing to provide more comprehensive teleoptometry services. As Optometrists expand their teleoptometry offerings, hopefully governments will recognize the value of these visits and public health may begin to fairly compensate Optometrists for their teleoptometry services.

- What are some concerns you have regarding telehealth and Optometry?

As we currently lean heavily on technology to provide teleoptometry services, I have concerns about liability. Right now, it seems the Optometrist is carrying a significant risk.

As well, there is also the concern of other professions encroaching on this territory and providing teleoptometry. If the Optometry profession cannot figure out how to embrace providing the teleoptometry services patients want, other opportunistic professionals and companies will surely take advantage of that.

- What advice do you have for an Optometrist hoping to offer telehealth?

There is certainly a place for teleoptometry in every clinical setting, whether that is full synchronous care, or just for follow-ups. Even some glaucoma workups can be done remotely with the current technology available. I hope Optometrists will embrace the opportunity of providing teleoptometry, as there are so many patients that can benefit from this mode of practice.

Interview 2:

- **When did you start providing telehealth? Walk us through a typical encounter. (e.g., describe synchronous or asynchronous care)**

I've been working in a telehealth setting ever since I first saw it applied in rural areas of Alaska in 2019. Due to the lack of available care the Alaska Indian Health Service was one of the forefront early adopters of both synchronous and asynchronous care.

Generally speaking, the synchronous telemedicine eye exam is practically the same as an eye exam with an in-person optometrist. The only difference is that the clinical data is collected by technicians who (probably) use more machinery than is typically used and the remote optometrist reviews the data remotely. Some machinery is remotely controlled (for example the digital phoropter).

- **Were there any barriers you've faced when setting up telehealth? (e.g., training of techs/nurses?) What about barriers to provide appropriate care? (e.g., perhaps not accurate enough equipment to actually diagnose assumed iritis virtually?)**

There's a large technological hurdle that all remote optometrists will have to face. Fortunately, I have always been good with software and programming, so I find technological challenges exciting and enjoy innovating solutions to current and upcoming problems.

Mental and professional barriers of providing appropriate care from behind a computer are harder to adapt to. Providing care remotely means you have less resources to compare with or rely on for reassurance that your diagnosis and management plan is right. The most important thing any optometrist can do is to be honest with what they can or cannot manage. Iritis is one example of many that are diagnosed heavily with careful listening to patient history. Even before you use the slit lamp a patient with unilateral photophobia and throbbing pain can be indicators of iritis that can be later correlated with other clinical findings including higher IOP in the fellow eye.

- **What are some benefits you have found with telehealth? What do patients say about it?**

One of the biggest benefits comes from setting up a remote lane in areas where it would not make financial sense for an optometrist to be working in-person. This enables more accessibility to eye care for patients in these areas and this increases doctor availability for patients. If patients can book an appointment at a more convenient location or sooner than an in-person visit, we can find and prevent potentially issues earlier. A pound of prevention is worth an ounce of cure...

We have a very positive reception. Before I started, I was more worried about the older generations being skeptical towards the new technology applications, but I couldn't have been more wrong. About once a week I am told that the eye exam I give is the most thorough one they have ever had. OCT is a standard test for our clinics, so often this is the first time a patient has ever had a macular/optic nerve scan and I'm able to show them the changes/findings on the screen in real time.

Another aspect behind telehealth exams that I was concerned about was the anticipated "lack of connection" between the patient and a doctor who is not in the same room. However, from my experience my patients and I have been able to establish a doctor patient relationship relatively easily. I found out a while later that there are papers (I can look for them) that show that "perceived eye contact" and full attention given in a synchronous telehealth environment often exceeds the attention that an in-person doctor delivers.

- **Where do you see telehealth and Optometry in 10 years?**

There's lots of different directions eye care in telemedicine and telehealth can go. Change is inevitable and is likely going to include improved technologies in the office and at home. Office based telehealth will continue to supplement care and reduce costs. At-home technologies including virtual reality and remote health monitoring applications will continue to become more prominent. My hope is optometry takes an active role to ensure these new applications ultimately continue to provide better and better patient care.

- **What are some concerns you have regarding telehealth and Optometry?**

a) Over-legislation. A real scenario is that the college boards and optometry associations have a knee-jerk reaction to something they don't understand and create under informed legislation out of fear and before understanding what the true applications of remote optometry can be. I don't think it would last forever but it would certainly stunt the growth.

b) Under-legislation. In my opinion this is the worst thing that could happen to telemedical eye care. This scenario is one where "anything goes" and it's basically what is happening in the US. Profit motivated optical chains will buy the cheapest equipment (definitely no OCTs, sometimes no VF!) and have optometrists that quickly see patients with limited data. This mentality is not sustainable and will inevitably lead to decreased quality of care for profit gains. As remote optometry gets a worse and worse reputation the colleges and associations will do their best to kill it completely. And THAT would be the worst thing for patients.

As a note, we must strive towards finding the "Goldilocks" amount of OD autonomy with respect to implementing synchronous telehealth.

- **What advice do you have for an Optometrist hoping to offer telehealth?**

Be honest. There is no such thing as a magic machine that does everything for you (at least not yet). That means you're still the clinician and you still need to make the evidence-based decisions on behalf of your patient. The only difference in synchronous telehealth is that you are more restricted to relying on the machines that you have and the technicians that are using them on your behalf. Also, get an OCT on everyone. That should be the standard of care anyways.

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